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EFFECTS OF SOME COVER TYPES ON INTERPLANTED FOREST TREE SPECIES

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EFFECTS OF SOME COVER TYPES

ON INTERPLANTED FOREST TREE SPECIES

By

A. G. Chapman and R. D. Lane

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INTRODUCTION

In the central hardwood region farmers or foresters often want to reestablish hardwood forests on old fields that are better suited to growing timber than to conventional agricultural crops. Attempts to establish nursery-grown planting stock of most of the more valuable hardwood species in old fields deteriorated by poor farming methods generally have failed. The trees either die or fail to grow satisfactorily.

Several features of the old field sites contribute to these planting failures. Most important perhaps are (1) compacted soils that are unfavorable to good available moisture supply and air conditions, (2) not enough of the minerals essential to good growth, and (3) not enough vegetational cover to protect the young trees from drying winds and great variations in temperature of both air and soil. Different species are affected differently by these factors.

A lack of sufficient mineral elements in old field soils usually does not affect survival and growth as much as the other factors mentioned. Lack of sufficient nitrogen, more than that of any of the other elements, is most likely to suppress growth, particularly of such species as yellow poplar (Liriodendron tulipifera L.), black walnut (Juglans nigra L.), wild black cherry (Prunus serotina Ehrh.), and green ash (Fraxinus lanceolata Borkh.). In his work on fertilizing hardwood tree seedlings, McComb (6) found that green ash, American elm (Ulmus americana L.), and Northern red oak (Quercus borealis var. maxima Marsh.) responded to nitrogen applications until the total nitrogen reached about two thousand pounds per acre. He also reported that black locust (Robinia Pseudo-Acacia L.) did not respond to nitrogen and Chapman (3) found that white oak (Quercus alba L.) seedlings did not respond significantly to this element. However, Cummings (4) noted good response of black locust to fertilizer applied at time of planting in eroded soils of low fertility. He obtained the best response when he mixed about 1/2 gram of N, 1 or 2 grams of P_2O_5, and 1/2 gram of K_2O with the soil in the planting hole for each tree.

To correct these old field site conditions adverse to good survival and growth of desirable hardwoods, the most promising approach is to seek natural vegetational covers or species which, when planted in old fields, will develop and improve the site as much as needed. When such cover is found, hardwood seedlings can be planted in mixture with or beneath it depending somewhat upon the rate of its development. If a suitable nurse cover cannot be found, the old fields must be planted to species of pines which usually will survive and grow well under such conditions. However, in the hardwood region these pines generally will produce only one crop before being succeeded by hardwoods, both good and poor, unless expensive silvicultural and replanting measures are taken. Regardless of the cover, no hardwood species should be planted unless it has previously grown successfully on the area and can withstand at least partial shading or the site is known to be suitable for its growth.

In 1940 a series of experimental plots was established in southern Illinois, followed by another in southeastern Ohio in 1941, to test the behavior of several species of planted hardwood seedlings under four planted and natural covers; that is, to find the best cover for each species. Also, in Vinton County, Ohio, in 1938 three pines--Eastern white (Pinus Strobus L.), pitch (Pinus rigida Mill.), and shortleaf (Pinus echinata Mill.)--were planted in mixture with black locust on similar old field sites to show the retarding effect of shade on these species. On this same area yellow poplar and green ash were planted in mixture with black locust to find the effects of locust on them.

EXPERIMENTATION

In both Illinois and Ohio species of hardwood seedlings were tested on sites with soils known to have grown the species or on soils similar to those that grow them. The Illinois plots were similar in origin and past agricultural use as were the Ohio plots. In Illinois the different covers were (1) natural old field herbaceous plants, grasses, and small shrubs, (2) sassafras (Sassafras albidum Nutt. Nees.), (3) planted black locust, and (4) planted pine. These covers were tested for their influence upon site and their effectiveness in stimulating the growth of planted yellow poplar, green ash, wild black cherry, and Northern red and white oaks.

In 1938 white, shortleaf, and pitch pines were planted in adjacent plots in Vinton County, Ohio, in mixture with locust and in pure plantings in old field cover. Yellow poplar and green ash were also planted in mixture with locust. In the mixed plantings each pine and each hardwood species was planted in 50 percent mixture in the row with black locust. Although the pine plots were not included in a formal experimental design, they demonstrated, as intended, that it is not desirable to mix these pines with hardwoods that have a faster growth rate. In 1950 height measurements were made and photographs taken to show differences in growth between the pines mixed and not mixed with locust.

DESIGN

On the Kaskaskia Experimental Forest in Illinois a randomized three-block design was used; each block contained one plot for each of the four cover types. Each plot contained two 20-tree rows of each of the five species, randomized in pairs. At the end of the third and ninth growing seasons survivals and heights were recorded. The significance of mean differences was determined by analyses of variance. The 1943 measurements given in table 1 show comparative behaviors of the planted species and relative effects of the covers at that time.

Table 1.--Mean 1943 survival percents and heights for five species planted in four covers in 1940 on the Kaskaskia Experimental Forest, Illinois

MEAN SURVIVAL

Covers	Species underplanted				
	White oak	Red oak	Black cherry	Yellow poplar	Green ash
			Percent		
Locust	93.3	93.3	93.3	89.1	98.3
Pine	93.3	95.8	95.0	72.5	95.8
Sassafras	92.5	85.0	90.8	93.3	95.0
Old field	74.2	73.3	81.6	31.6	98.3

MEAN HEIGHT

			Feet		
Locust	3.1	2.3	5.5	7.5	4.5
Pine	1.2	1.1	3.4	3.8	3.0
Sassafras	1.1	1.6	1.7	3.0	1.9
Old field	1.4	1.6	1.7	1.9	2.2

Two covers in Ohio--old field and planted black locust--were tested for their relative effects upon planted yellow poplar, green ash, and red and white oaks. The tests were made on three randomized blocks on the Athens Ranger District of the Wayne National Forest Purchase Units. Each block contained three plots; on each

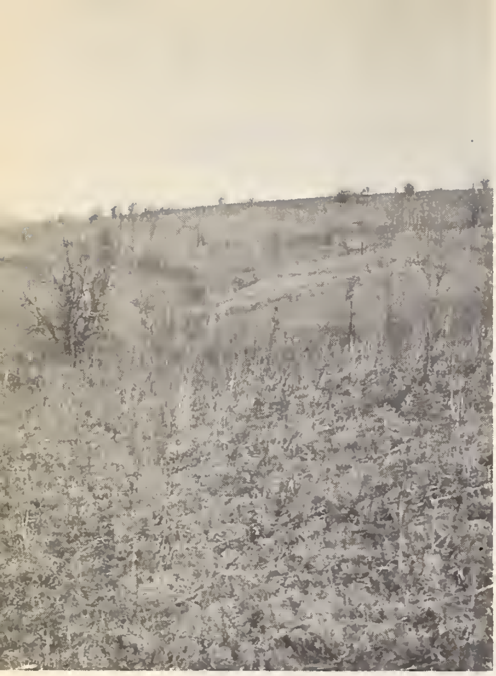


Figure 1.--Typical old field cover of poverty grass, broomsedge, and several species of shrubs and small trees. Much of the planting in the central states is done on fields like this.

plot the four species were assigned at random in units of three rows, a total of 36 trees of each species. After eight growing seasons survival counts and heights were recorded and analyzed by analysis of variance for significant differences in behavior by species under the two covers.

COVERS

In Illinois and Ohio most of the planting is done on old fields once used for farming but now with typical cover of broomsedge (Andropogon virginicus L.), poverty grass (Danthonia spicata L.), herbaceous weed species, and a few scattered shrub species (fig. 1). In southern Illinois, but not in Ohio, sassafras is commonly the first woody species to develop a tree cover of any consequence in old fields. In the past, most attempts at planting hardwood seedlings in old field covers failed. Therefore, the most logical covers in which to test hardwood planting, other than old field, were sassafras, planted black locust, and planted pine.

These three covers--the locust and pine spaced 6 by 6 feet--were from 8 to 10 feet in height at time of interplanting and had canopies of about equal densities; at the outset they permitted about the same amounts of light to reach the ground and the planted hardwoods (figs. 2, 3, and 4).

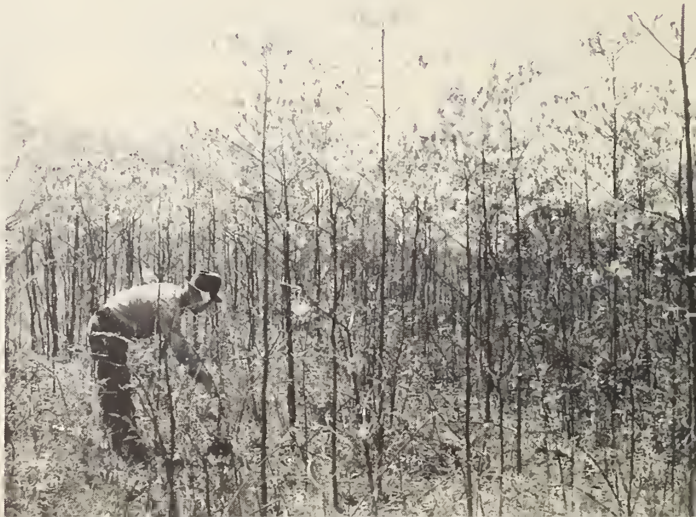
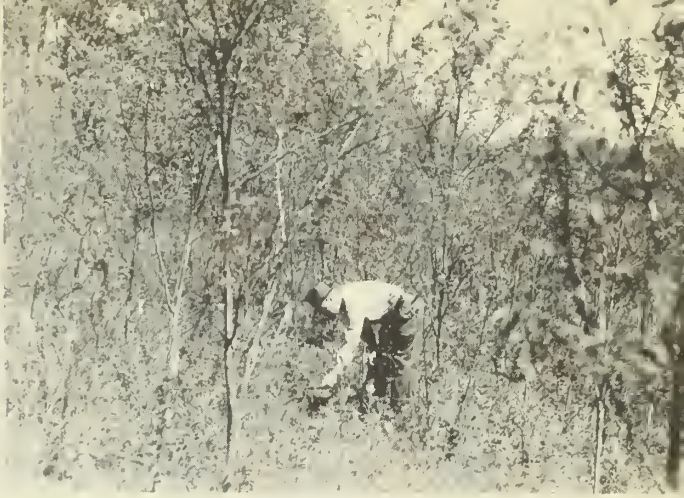


Figure 2.--Cover of sassafras in southern Illinois old field where five hardwoods were planted.

Figure 3.--Four-year-old planted black locust in same old field as sassafras in figure 2 and interplanted with the five hardwoods.



RESULTS AND DISCUSSION

Since the Illinois and Ohio tests of vegetational covers were made in two separate random block designs, the results are reported separately. Four covers and five planted species were employed in Illinois in 1940 and only two covers and four species in Ohio in 1941. In addition to the interplanted hardwood tests, results of three pines planted with and without black locust in old field cover in Ohio in 1937 are reported to answer frequent queries on the advisability of such mixtures.

ILLINOIS PLOTS

Table 1 shows the mean survival percent and the mean height in feet by species of planted trees and cover. Notice that a few significantly low survival percents appear to be due either directly or indirectly to cover. Only the old field cover showed generally low survival. This is what we would expect; most attempts at planting hardwood seedlings in old field cover have failed. The failures are caused by the rigorous conditions of the site--that is, great variations in soil moisture and soil and air temperatures.

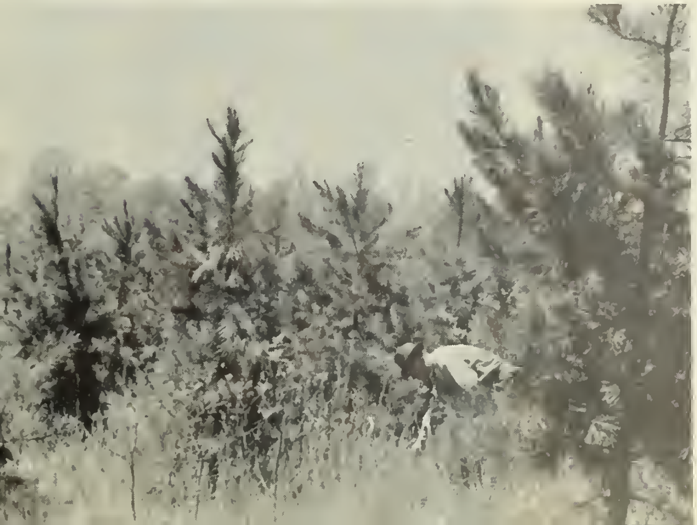


Figure 4.--Four-year-old planted pitch pine adjacent to the locust and sassafras shown in figures 2 and 3 interplanted with the five hardwoods.

Also because the trees are not protected from drying winds, transpiration rates are high. Green ash alone survived exceptionally well in all plots as has been observed generally throughout its planted range. It is one of the relatively few hardwoods that can withstand the rigors of old field planting sites although its growth rate and form may not be satisfactory.

Unquestionably, some of the trees were killed by shading by the dense canopies developed in parts of the sassafras, pine, and black locust plots after the test plantings. However, the shade cast by patches of lush blackberry and other rank undergrowth killed more of the trees than the shade from the locust canopy.

Yellow poplar under shortleaf and pitch pines had 72.5 percent survival at the end of the fourth growing season. An unusually dry summer in 1947 in southern Illinois reduced poplar survival to 5.0 percent under pine but the other species in the several covers were not so noticeably affected. This confirms the observation that yellow poplar seedlings are usually more susceptible to drought injury than most other hardwood seedlings particularly when they are shaded, and that it is necessary to plant the species on sites where soil moisture is plentiful. Why was the pine cover more adverse to yellow poplar than the other covers, including old field? The most plausible explanation is that pine does not improve the water infiltration rate and the water-holding capacity of compacted old field soils to the same extent or as rapidly as do hardwoods. Furthermore, the pine needle litter sheds water to a greater extent than hardwood or herbaceous litter.

Figure 5 shows one of the tallest 1940 planted green ash trees in shortleaf pine in Illinois.

Although no definite records were kept on the amount of rabbit clipping, it caused some mortality. The two oak species suffered the most injury; many of the trees were repeatedly cut back.

Usually in open field plantings most of the mortality occurs during the first and second growing seasons following planting. But the interplantings made in overtopping covers indicate that as much or even more mortality may be

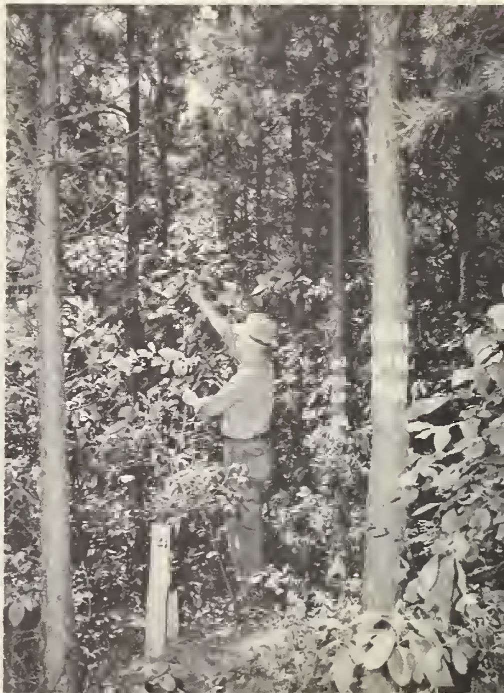


Figure 5.--Green ash after nine years in the pine shown in figure 4.

expected after four or more years because of increased competition (tables 1 and 2). In spite of this, with the exception of yellow poplar in pine, there is still an adequate stocking for future growth in the plots.

Table 2.--Mean 1948 survival and heights for five hardwood species planted in four covers in 1940 on the Kaskaskia Experimental Forest, Illinois

MEAN SURVIVAL

Covers	Species underplanted				
	White oak	Red oak	Black cherry	Yellow poplar	Green ash
	- - - -	- - - -	Percent	- - - -	- - - -
Black locust	71.7	46.0	91.7	82.5	93.3
Pine	89.2	90.8	91.7	5.0	95.0
Sassafras	78.3	60.8	76.7	81.7	89.2
Old field	58.3	55.8	79.1	22.5	94.8

MEAN HEIGHT

Covers	White oak	Red oak	Black cherry	Yellow poplar	Green ash
	- - - -	- - - -	Feet	- - - -	- - - -
Black locust	4.4	7.1	14.1	16.6	5.2
Pine	2.2	2.1	6.9	5.5	5.1
Sassafras	1.9	3.1	2.7	6.3	2.5
Old field	1.8	3.2	2.5	3.5	2.8

MEAN HEIGHTS OF 25 PERCENT OF TALLEST LIVING TREES

Covers	White oak	Red oak	Black cherry	Yellow poplar	Green ash
	- - - -	- - - -	Feet	- - - -	- - - -
Black locust	7.3	11.4	20.2	22.4	7.2

The important effects of covers upon height growth of species are shown in tables 1 and 2. Notice that black locust as a nurse cover is far superior to any of the other covers tested; yet all species do not respond alike to associated locust. In the 1943 measurements (table 1) the green ash under locust was significantly better than under any other cover. The mean height differences for all species, except green ash under pine, between locust cover and any other cover are highly significant (table 2). The beneficial effects of locust show up soon after the trees are underplanted and apparently continue throughout the development of the plantation.

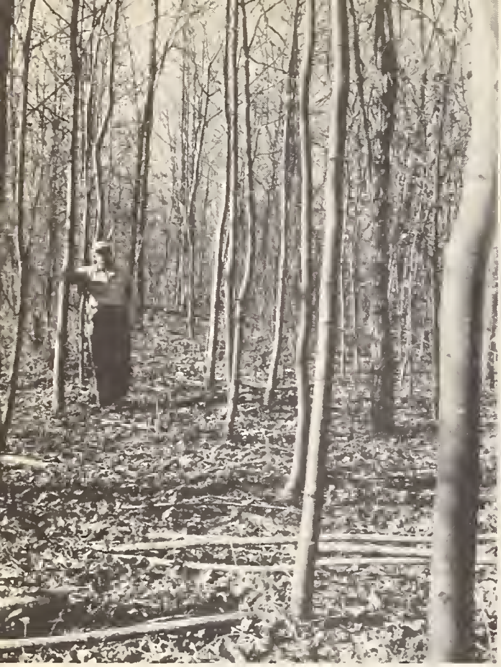


Figure 6.--Yellow poplar after nine years in the black locust shown in figure 3. Locust is mostly decadent because of locust borer attack.

We believe that once hardwood plantings are well established under improved site conditions, as those in locust seem to be, they will continue to develop well.

Some hardwood species respond more than others to the additional nitrogen provided by locust (1). Yellow poplar and black cherry, for example, show distinctly better growth in all plots where they were associated with locust. The other planted species responded but not to such a great extent. Relative responses of white oak and yellow poplar to different amounts of nitrogen have been reported in previous work (2) (3).

The extremes of behavior by yellow poplar and black cherry are shown in figures 6 and 7, on the one hand, and figure 8, on the other. Figures 6 and 7 show underplanting in locust; figure 8 shows an old field planting. At time of planting the ground cover in all three plots was similar to that in figure 8. In the past few years most of the locust trees have been badly damaged by the locust borer and, as shown, are largely dead or broken. Only a few are alive and have good form. In spite of this damage the chief nitrogen benefit has been obtained; the nitrogen cycle has been established, the canopy has opened admitting more light, a good litter has formed, and the first 6 inches of soil is friable enough to provide excellent moisture and air conditions for root growth. In contrast, only a few of the trees planted in old fields are visible above the cover (fig. 8). Here the site is little better than at the time of planting, nine years before. Certainly if locust has no other value than to improve the site

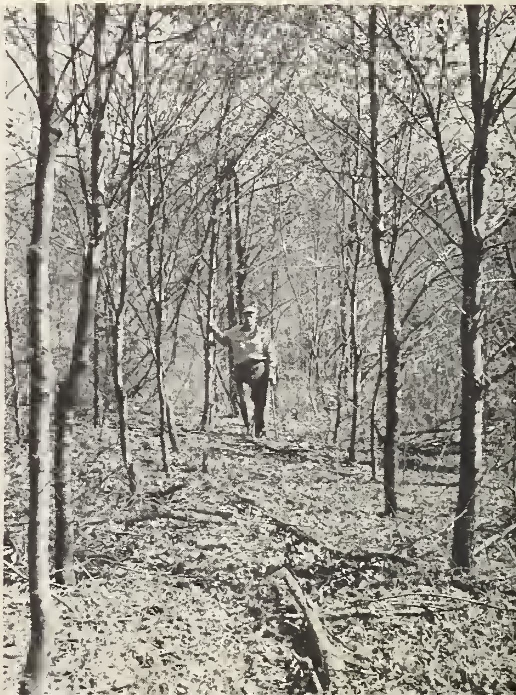
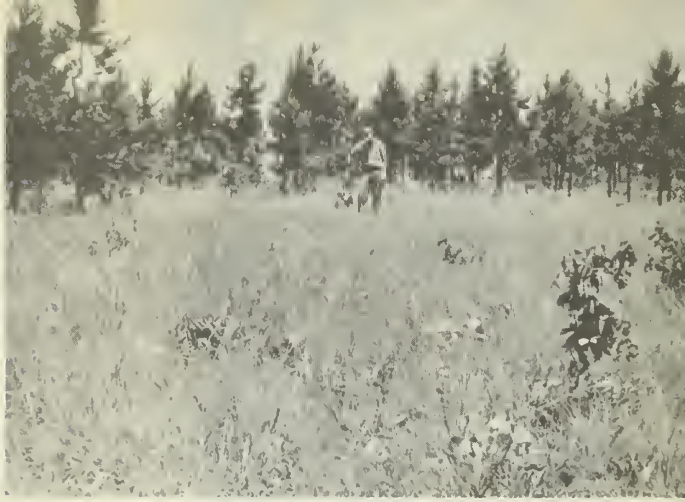


Figure 7.--Black cherry after nine years in black locust shown in figure 3.

Figure 8.--Opening is old field cover plot in Perry County, Ohio, where four species of hardwoods were planted. The same year, 1941, the surrounding shortleaf pine was planted.



and stimulate the growth of associated hardwoods, the cost of its planting is fully justifiable.

The mean heights in table 2 are based upon heights of all living planted trees. However, these alone do not show the great variation in height growth in the locust cover. Many trees are suppressed by overtopping shortly after planting by lush ground cover stimulated by high nitrogen and improved soil conditions. Mean heights of dominant and codominant trees, many of which will become harvest trees, far exceed the general means. The number of suppressed trees is greater for the more tolerant species than for the less tolerant; many of the latter die when overtopped. The mean heights for 25 percent of the tallest living trees under locust are shown for comparison in table 2.

The beneficial effects of black locust upon the growth of planted hardwoods are substantiated by early results of similar test plantings on strip-mined lands in Illinois. Three years after planting the total height of black walnut and yellow poplar planted under decadent black locust was three to four times greater than that planted on exposed mine banks (5).

There are some disadvantages to planting trees in locust plantations which may be overcome by planting the desired hardwoods and locust simultaneously. Survival would probably be better and height growth more uniform because there would be less overtopping by lush ground cover during the early years of the plantation. The stems of both yellow poplar and black cherry in figures 6 and 7 are somewhat crooked as a result of whipping of the tops when the terminal branches were penetrating the locust canopy. This is not desirable, yet not a serious condition, since the tree boles will straighten with age and enough are unaffected to compose a full stand of final harvest trees. In figures 9 and 10, representing simultaneous mixtures of locust and yellow poplar and locust and green ash respectively, crooked stems are not so common nor

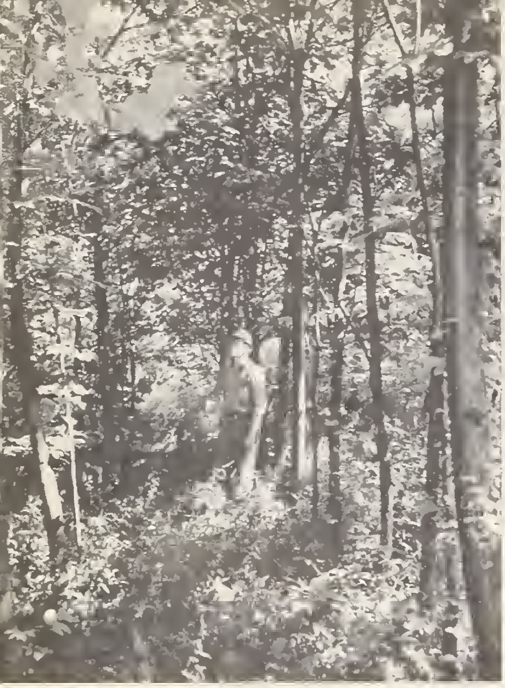


Figure 9.--Thirteen-year-old yellow poplar planted in mixture with black locust in old field, Vinton County, Ohio, in 1938. Dominant and codominant trees have a mean height of 32 feet.

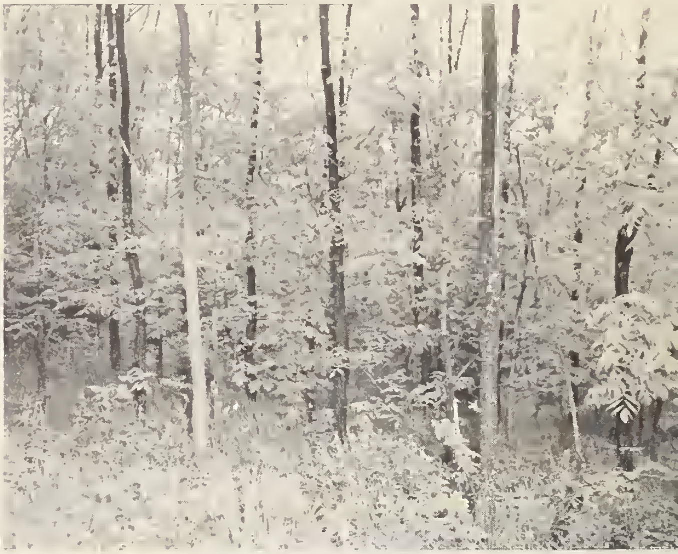


Figure 10.--Thirteen-year-old green ash planted in mixture with black locust in same old field as indicated in figure 12. Dominant and codominant trees have a mean height of 21 feet.

are those affected so crooked. Finally, tree spacing can be better controlled if locust and the other hardwoods are planted in original mixtures.

Much of the sassafras in southern Illinois grows on lands originally occupied by oak-hickory forest, cleared, and rapidly deteriorated by poor farming methods. Planting yellow poplar or other species with similar site requirements in these areas is highly inadvisable. Even oak species usually fail except on the better sites. The problem resolves itself to one of spot planting one or more of the shade-intolerant southern yellow pines in the openings or destroying the sassafras through physical or chemical means, then planting the entire area. Destroying or opening-up dense sassafras stands for pine planting is costly and would be justified only in special cases.

OHIO PLOTS

Table 3 contains the mean survival percent and the mean height in feet for the Ohio plots by planted species and the two covers, black locust and old field. With the exception of yellow poplar, all species showed poorer survival in old fields than under black locust because of the more rigorous conditions of the old field sites. The yellow poplar low survival of 51.4 percent under locust was not. as in the Illinois plots, caused by the locust shade but by large patches of rank blackberry and other growth forming a dense canopy over the seedlings before they became well established. The other three species were also overtopped by undergrowth in locust but were not so adversely affected.

Table 3.--Mean 1948 survival and heights for four species planted in black locust and old field covers in 1941 in Vinton and Perry Counties, Ohio

MEAN SURVIVAL

Covers	Species underplanted			
	Yellow poplar	Green ash	Red oak	White oak
	Percent			
Black locust	51.4	74.1	81.9	74.1
Old field	78.3	60.5	72.7	58.3

MEAN HEIGHT

	Feet			
Black locust	12.5	8.2	5.2	3.1
Old field	4.0	3.0	2.8	1.3

MEAN HEIGHTS OF 25 PERCENT OF TALLEST LIVING TREES

	Feet			
Black locust	17.1	10.6	6.4	5.9

Height growth was significantly greater under locust for all species. Yellow poplar had the best growth rate. Because heights of all trees for each species were used in computing table 3 means, including trees suppressed by overtopping clumps of blackberry and other rank undergrowth, the table means do not show the full stimulating effects of the locust. To give a better picture of the affect of the locust cover, 25 percent of the tallest living trees of each species were selected and their means reported for comparison with the general means in table 3. A few of the suppressed trees will eventually grow through their suppressing covers, but more will die unless released by clearing.

Results of the 1938 plantings of three pines in old field cover, with and without black locust, are given in table 4. The fact that all shortleaf and pitch pine trees died is in accordance with previous observations that when these species are overtopped by any cover casting as much shade as the closed canopy of a young locust stand the trees died in one or two seasons. For this reason it is not advisable to mix these pine species with species that are certain to overtop them.

Table 4.--Mean heights of three species of pine planted with and without black locust in Vinton County, Ohio, in 1938 and measured in fall of 1950

Covers	Planted species		
	White pine	Shortleaf pine	Pitch pine
	- - - - - - - - - - -Feet-	- - - - - - - - - -	
Black locust	10.5	(1/)	(1/)
Old field vegetation	24.0	25.0	23.5

1/ All dead.

White pine, on the other hand, is more shade-tolerant; its growth is greatly retarded by overtopping locust but it is not killed. The behavior of white pine growing with (fig. 11) and without (fig. 12) locust in old fields is the direct opposite of yellow poplar and other tolerant hardwoods which respond to increase in nitrogen supply, as shown by the 10.5-foot mean under locust and the 24.0-foot mean not under locust in 12 years. Although the

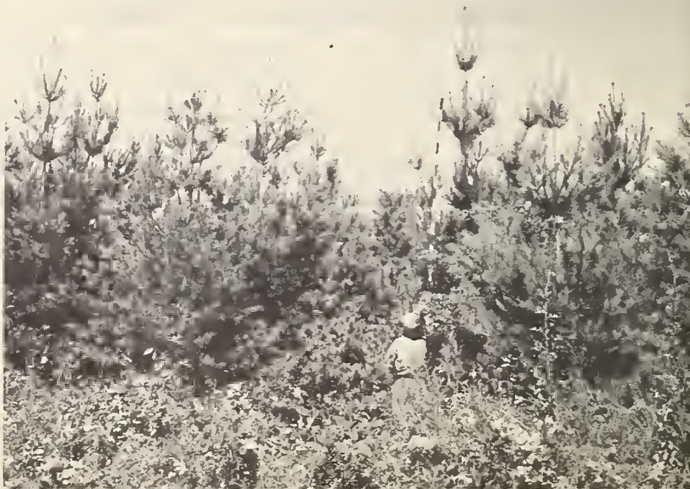


Figure 11.--White pine planted in Vinton County, Ohio, in 1937 in old field cover. Photo made in 1948.

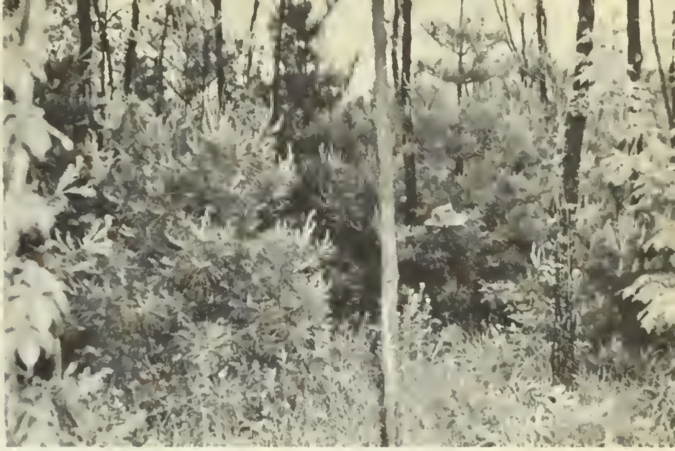


Figure 12.--White pine mixed with black locust in planting in 1937 in old field adjacent to planting shown in figure 8. Photo made in 1948.

species does survive when mixed in planting with black locust, there is no good reason why this should be done if the purpose is to establish a pine stand.

RECOMMENDATIONS

These recommendations are based upon inferences drawn from the behavior of the plantings discussed in this paper:

1. To establish hardwood plantings in old fields, plant the desired species in mixture with two-thirds to three-fourths black locust. Locust has proved to be the best nurse crop tested for its effects upon associated hardwood species. Only species which are known to have grown well on the planting site or are adapted to the specific site should be used.

2. Plant the hardwoods with locust at the same time rather than underplanting them after the locust is well established. This will avoid two planting projects and the difficulty of planting in the heavy undergrowth common in locust stands. Furthermore, there is less danger of severe competition and loss from heavy ground cover such as blackberry briars, and less likelihood of whipping damage.

3. Since hardwoods can be well established in mixture with locust, more should be used in old field reforestation. This will shorten the time necessary to again obtain valuable hardwood stands by the rotation length of the pines usually used. This is recommended unless some specific use is planned for pine species.

4. Avoid mixing pine species with black locust or any other hardwood with a faster growth rate since overtopping will starve such yellow pines as shortleaf and pitch and greatly retard growth of the more shade-tolerant white pine.

SUMMARY

1. Plantings were made in Illinois in 1940 to test yellow poplar, black cherry, green ash, and red and white oaks planted in four covers--old field, sassafras, planted pine, and black locust. In Ohio in 1941, yellow poplar, green ash, and red and white oaks were tested in old field and black locust covers. In 1937, yellow poplar, green ash, and pitch, shortleaf, and white pines were planted in mixture in old fields with and without black locust.

2. Among all the covers in which hardwood species were planted, black locust proved to be greatly superior as a nurse crop to any others for both survival and growth. Other covers in order of their values were pine, sassafras, and old field.

3. Hardwoods, properly selected for the planting site and tolerant to shaded conditions created by locust, can better be planted in mixture with locust in one operation than by underplanting after the locust is well established. It requires but one planting operation whereas underplanting requires two.

4. Even though planted black locust may fail to produce usable products because of locust borer damage, the cost of planting it is believed justifiable because it improves the site rapidly and permits early establishment of associated hardwood species.

5. Of the five hardwood species tested in association with locust, yellow poplar responded best, green ash and black cherry next, and the two oaks least to the effects of locust on the site.

6. Shortleaf and pitch pines which are intolerant to shade suffered complete mortality when planted with black locust. White pine is more tolerant to shade and when planted with black locust cover had good survival. However, its growth in black locust was much less than in the old field cover.

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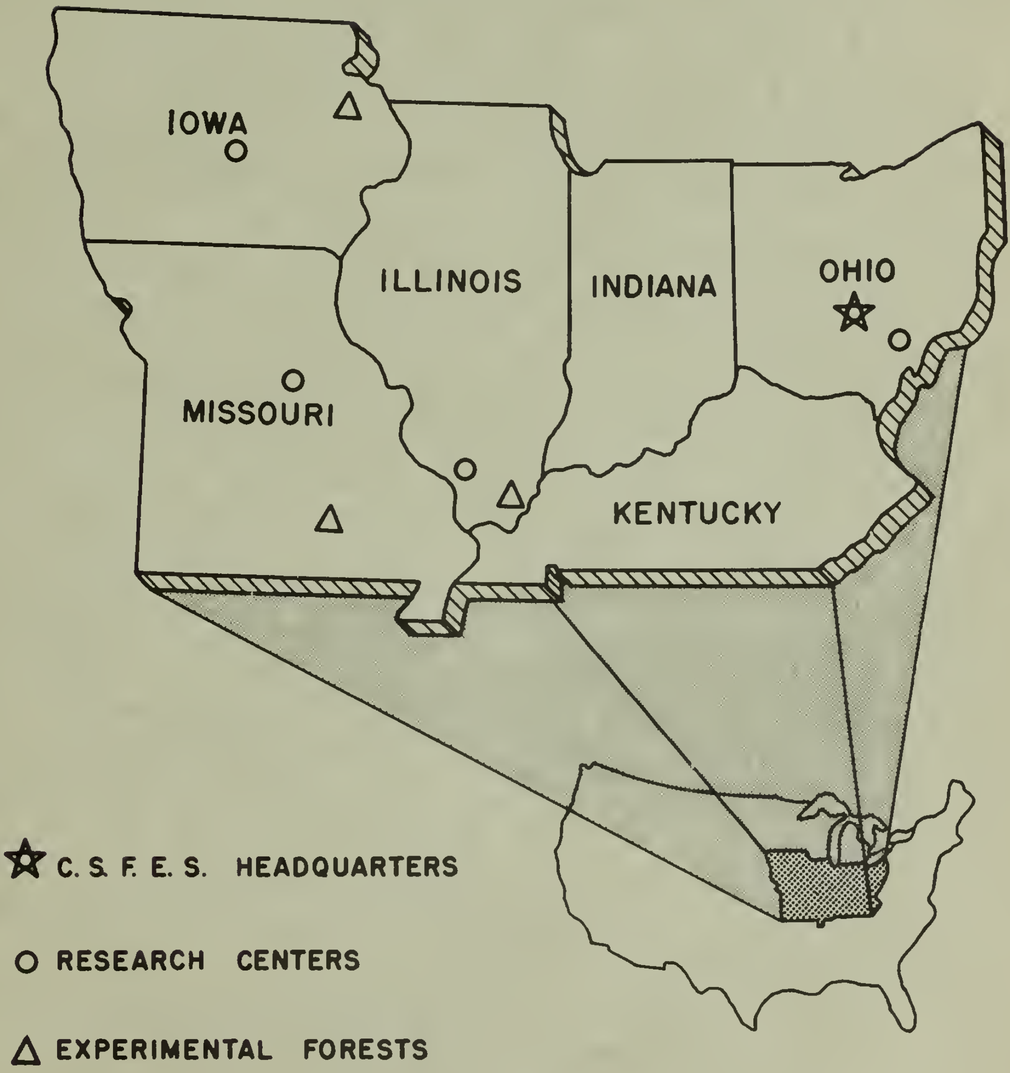

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